**Game Changing Development**

# Dedicated Slosh Dynamics Experiment on ISS using SPHERES (Advanced Space Operations in CR)

Completed Technology Project (2011 - 2014)

## Project Introduction

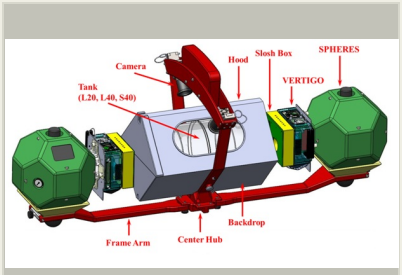
At the Kennedy Space Center (KSC) the Launch Services Program is leading an effort to conduct an experiment aboard the International Space Station (ISS) to validate computational fluid dynamics (CFD) models. As spacecraft missions get longer and more ambitious, it becomes increasingly important that we fully understand the location and movement of liquids inside the propellant tanks of these vehicles. It is essential to understand how the movement of the liquid propellant will affect the trajectory of the vehicle. Current CFD models should predict these dynamics, but because test data is lacking, the accuracy of the models is not well understood. The slosh experiment aboard the ISS sets out to acquire this type of data.

The Synchronized Position, Hold, Engage, Reorient, Experimental Satellites – VERTIGO (SPHERES-VERTIGO) developed by the Massachusetts Institute of Technology (MIT)—are free-floating, soccer-ball-sized robots with their own propulsion and power. They are used aboard the ISS to study formation flight and other control system algorithms. For this experiment, these same SPHERES will be programmed with thruster firings that will emulate common maneuvers carried out by launch vehicles and spacecraft. This motion will impart energy to the fluid inside the experiment, which will measure its effects. The ISS provides the perfect environment to conduct liquid behavior studies in microgravity. This investigation is planned to collect valuable data on how liquids move around inside of a container when external forces are applied to that container – this simulates how rocket fuels move around inside their tanks when motor thrusts are used to push the rocket through space. The slosh experiment takes advantage of hardware already on the ISS. The primary slosh experiment component is a clear, pill-shaped Lexan tank in the middle of the assembly. This tank is shrouded by a tan box designed to prevent the ISS ambient lights from interfering with the cameras. Also in the middle, is the center hub made of aluminum. This center hub has two arms to hold two high-resolution cameras. These cameras will collect video of the fluid inside the tank. The center hub assembly is connected to a larger frame, which connects to the two SPHERES units through a clamp system. VERTIGO computers attached to the SPHERES units will collect the data from the cameras and the onboard inertial measurement units. These computers are already on the ISS and will be used by the slosh experiment as storage and power for the cameras and accelerometers.

## Anticipated Benefits

Currently funded NASA missions will be able to design more efficient trajectory profiles which will allow them to increase mission lifetimes and decrease risk. Validated models from this experiment will be used to predict the motion of liquid propellants inside the tanks of future space missions increasing safety, performance, and reliability.

Powerful rockets use liquid fuel to bring satellites into orbit, and are subjected




Dedicated Slosh Dynamics Experiment on ISS

## Table of Contents



## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Kennedy Space Center (KSC)

**Responsible Program:**

Game Changing Development

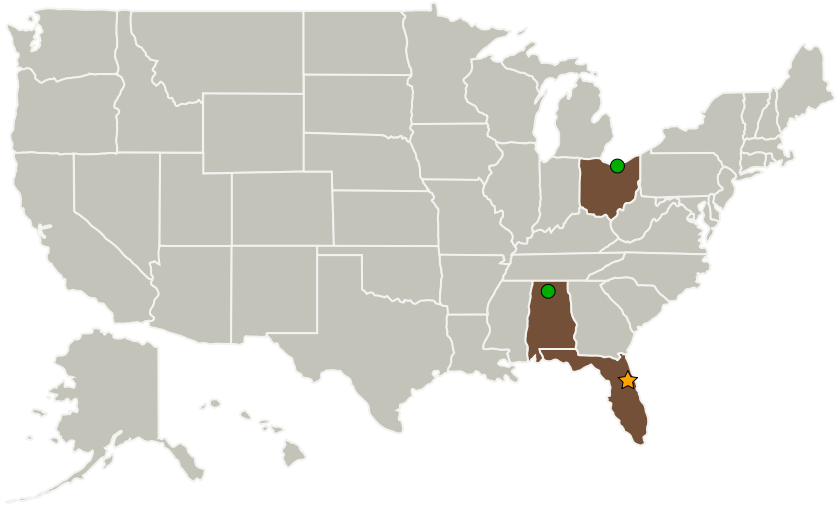
# Dedicated Slosh Dynamics Experiment on ISS using SPHERES (Advanced Space Operations in CR)

Completed Technology Project (2011 - 2014)

to varying forces as they are propelled forward. But computer simulations may not accurately represent how liquids behave in low-gravity conditions, causing safety concerns. The Slosh experiments improve these models, and thereby improve rocket safety, by measuring how liquids move around inside a container when external forces are applied to it. This simulates how rocket fuels swirl around inside their tanks while a rocket moves through space. The data from this experiment can then be used to check computer simulations on how rockets work, ultimately leading to rockets and spacecraft that are more reliable, safer and cost effective.

Data from this experiment will allow for greater confidence in the performance of future missions, as well as improve safety for both manned and unmanned missions. The commercial space industry and any other government agencies will be able to use the data collected and the information learned from the analysis of that data which will impact the ability to improve the performance of rockets and spacecraft.

### Primary U.S. Work Locations and Key Partners



## Project Management

**Program Director:**

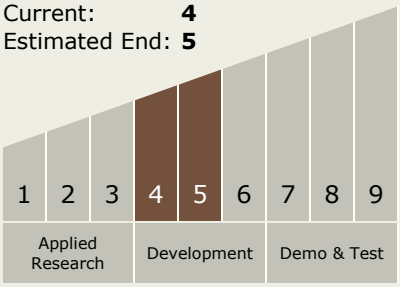
Mary J Werkheiser

**Program Manager:**

Gary F Meyering

## Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **5**




## Technology Areas

**Primary:**

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.4 Environmental Monitoring, Safety, and Emergency Response
    - TX06.4.2 Fire: Detection, Suppression, and Recovery

**Game Changing Development**

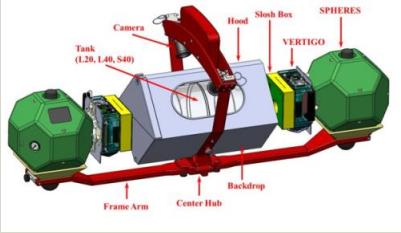
# Dedicated Slosh Dynamics Experiment on ISS using SPHERES (Advanced Space Operations in CR)

Completed Technology Project (2011 - 2014)

| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Kennedy Space Center(KSC) | Lead Organization | NASA Center | Kennedy Space Center, Florida |
| ●Glenn Research Center(GRC) | Supporting Organization | NASA Center | Cleveland, Ohio |
| ●Marshall Space Flight Center(MSFC) | Supporting Organization | NASA Center | Huntsville, Alabama |

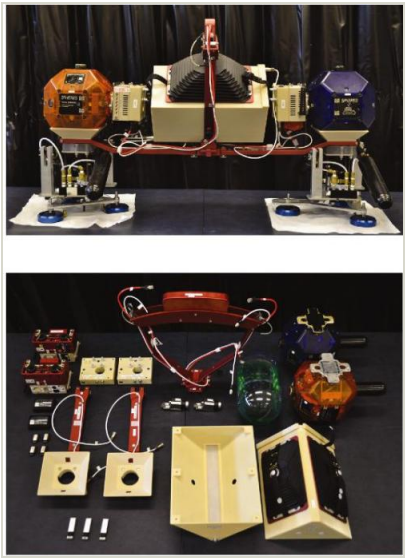
| Primary U.S. Work Locations | |
|---|---|
| Alabama | Florida |
| Ohio | |

## Images




**Dedicated Slosh Dynamics Experiment on ISS using SHPERES**
Dedicated Slosh Dynamics Experiment on ISS
*(https://techport.nasa.gov/image/2064)*

**Dedicated Slosh Dynamics Experiment on ISS using SPHERES**
Dedicated Slosh Dynamics Experiment on ISS using SPHERES (Advanced Space Operations in CR)
*(https://techport.nasa.gov/image/2063)*



**Slosh Experiment Components**
Fully assembled slosh experiment (top); slosh experiment components (bottom)
*(https://techport.nasa.gov/image/3429)*